CLAIMS:

1. A fuel cell assembly comprising:

a plurality of separate elements;

at least one groove network extending through the fuel cell assembly and including at least one filling port for the groove network; and

a seal within each groove network that has been formed in place after assembly of said separate elements, wherein the seal provides a barrier between at least two of said separate elements to define a chamber for a fluid for operation of the fuel cell.

2. A fuel cell assembly as claimed in claim 1, wherein the groove network comprises a plurality of closed groove segments, each of which comprises at least a groove segment in one of said separate elements that faces and is closed by another of said separate elements, thereby to form said closed groove segments.

3. A fuel cell assembly as claimed in claim 2, wherein at least some of said closed groove segments each comprise a first groove segment in one of said separate elements facing a second groove segment in another of said separate elements.

4. A fuel cell assembly as claimed in claim 2, which comprises a plurality of individual fuel cells.

5. A fuel cell assembly as claimed in claim 4, wherein each fuel cell comprises a plurality of separate elements, each of which includes a connection aperture, whereby the connection apertures form a connection duct of the groove network extending through each fuel cell, and wherein the connection ducts of individual fuel cells are interconnected and are connected to said at least one filling port, whereby the groove network extends through a plurality of fuel cells, to enable a seal for all of the fuel

cells to be formed substantially simultaneously and wherein the seal has been formed by injection of a liquid elastomeric seal material and subsequent curing of the elastomeric seal material.

6. A fuel cell assembly as claimed in claim 5, which comprises a plurality of proton exchange membrane fuel cells, each of which comprises an anode flow field plate, a cathode flow field plate, a membrane electrode assembly including a proton exchange membrane and located between the anode and cathode flow field plates, a first gas diffusion layer between the anode flow field plate and the membrane electrode assembly and a second gas diffusion layer between the membrane electrode assembly and the cathode flow field plate, wherein at least the anode and cathode flow field plates define apertures for forming, with apertures of other fuel cells, ducts for fuel, an oxidant and a coolant.

7. A fuel cell assembly as claimed in claim 6, wherein each anode flow field plate and each cathode flow field plate include recesses to accommodate the first and second gas diffusion layers, and wherein portions of the anode and the cathode flow field plates of each fuel cell not separated by the membrane electrode assembly are separated by an insulator, whereby compression of the first and second gas diffusion layers is determined by the dimensions of said recesses.

8. A fuel cell assembly as claimed in claim 6, wherein facing surfaces of each pair of anode and cathode flow field plates have substantially flat opposed faces, and the gas diffusion layer and membrane extend substantially to edges of the flow field plates.

9. A fuel cell assembly as claimed in claim 8, wherein surfaces of the anode and cathode flow field plates include grooves for the elastrometric seal material that fills the grooves and penetrates the gas diffusion layers, to form a seal with the membrane.

10. A fuel cell assembly as claimed in claim 9, wherein each proton exchange membrane includes a peripheral flange, and the seal material is bonded to the peripheral flanges.

11. A fuel cell assembly as claimed in claim 8, 9 and 10, wherein each flat, opposed face of the anode and cathode flow field plates includes flow field channels for gases.

12. A fuel cell assembly as claimed in claim 10, which comprises a membrane electrode assembly intended for assembly with similar membrane electrode assemblies into a larger fuel cell stack, the fuel cell assembly including, at either end thereof, end surfaces adapted for mating with end surfaces of similar membrane electrode assemblies.

13. A fuel cell assembly as claimed in claim 12, wherein at least one of said end surfaces is provided with a seal, for forming a seal with the end surface of another similar membrane electrode assembly.

14. A fuel cell assembly as claimed in claim 10, wherein each of the anode and cathode flow field plates includes, at one end thereof, a first fuel aperture, a first coolant aperture and a first oxidant aperture, and at the other end thereof, a second fuel aperture, a second coolant aperture and a second oxidant aperture; wherein each of the anode and cathode flow field plates includes a first connection aperture at said one end and a second connection aperture at said other end for supply of material to form said seal.

15. A fuel cell assembly as claimed in claim 14;

wherein the anode flow field plate includes on a rear face away from the membrane electrode assembly, a groove network portion including groove elements that extend around the fuel and oxidant apertures and that extend only partially around the coolant apertures, thereby to enable coolant to flow between the coolant apertures across the rear face thereof, wherein

a second groove network portion is provided on the front face of the anode flow field plate and includes groove segments extending around at least the oxidant and coolant apertures, the anode flow field plate including a channel network, on the front face thereof, to distribute fuel gas over the first gas diffusion layer; and

wherein the cathode flow field plate includes a third groove network portion on the rear face thereof, away from the membrane electrode assembly, including groove elements that extend around the oxidant and fuel apertures and that extend only partially around the coolant apertures, thereby to enable coolant flow across the rear face thereof between the coolant apertures; and wherein a fourth groove network portion, on the front face of the cathode flow field plate, includes groove segments extending around at least the fuel and coolant apertures, the cathode flow field plate including a channel network, on the front face thereof, to distribute oxidant gas over the second gas diffusion layer.

16. A fuel cell assembly as claimed in claim 14 or 15, wherein each of the connection apertures is positioned to intersect groove segments around the coolant and fuel apertures.

17. A fuel cell assembly as claimed in claim 16, wherein the groove segments are dimensioned and are of a shape and size to provide substantially similar filling times, with longer groove segments being provided with larger cross sections, thereby to prevent occurrence of air pockets

18. A fuel cell assembly as claimed in claim 17, which includes vents extending between the groove network and at least one of the exterior of the fuel cell assembly and internal chambers within the fuel cell assembly, the vents being dimensioned to permit air to escape and being small enough to cause pressure to build up in the elastomeric material to ensure complete filling of the entire groove network.

19. A fuel cell assembly as claimed in claim 18, wherein each element includes at least two connection apertures and a plurality of vents located substantially equal distance between the connection apertures thereof, for venting air during filling of the groove networks.

20. A fuel cell assembly as claimed in claim 2, which includes an external sealing layer formed around the exterior of the fuel cell assembly and formed from the same material as said seal within each groove network, wherein connections are provided between each groove network and the exterior of the fuel cell assembly and said external sealing layer and said seal within each groove network have been formed in place simultaneously.

21. A fuel cell assembly as claimed in claim 20, wherein the fuel cell assembly comprises a plurality of individual fuel cells located between two end plates and wherein the external sealing layer encloses all the fuel cells and extends between the two end plates.

22. A fuel cell assembly as claimed in claim 2, which includes at least one fuel cell and, one side, a seal molded in place and adapted to abut the other side of another, similar fuel cell assembly to form a chamber for coolant, whereby a plurality of said fuel cell assemblies can be assembled together to form a large fuel cell unit assembly with coolant chambers being formed between adjacent fuel cell assemblies.

23. A method of forming a seal in a fuel cell assembly comprising a plurality of separate elements, the method comprising:

(a) assembling the separate elements of the fuel cell together;

(b) providing a groove network extending through the separate elements and a filling port open to the exterior in communication with the groove network;

(c) connecting a source of uncured liquid seal material to the filling port and injecting the seal material into the groove network to fill the groove network and simultaneously venting gas from the groove network; and

(d) curing the seal material, to form a seal in the groove network.

24. A method as claimed in claim 23, which includes filling the groove network for a predetermined time at a predetermined pressure, to ensure filling of the groove network.

25. A method as claimed in claim 24, which includes providing said separate elements with groove segments, for forming the groove network, and cleaning the groove segments prior to assembling the separate elements, to promote bonding of the seal material to the separate elements.

26. A method as claimed in claim 25, which includes providing surfaces of the separate elements with a primer, to promote bonding of the seal material thereto.

27. A method as claimed in claim 26, which includes priming the separate elements by one of:

applying a primer in liquid form to the separate elements;

plating a primer onto the separate elements; and

incorporating a primer material within the material of selected separate elements so as to improve the bonding capability of the surface of each such separate element to the seal material.

28. A method as claimed in claim 24, which includes providing a liquid silicone elastomeric material as the seal material and curing the seal material at an elevated temperature for a predetermined time.

29. A method as claimed in claim 28, which includes curing the seal material by passing heated water through the fuel cell assembly.

30. A method is claimed in claim 28, which includes preheating the assembled stack, prior to filling with groove network with seal material.

31. A method as claimed in claim 24, which includes providing the separate elements with groove segments for forming the groove network, assembling the separate elements together in abutting relationship and clamping the separate elements together, prior to injecting the seal material into the groove network.

32. A method as claimed in 31, which includes mounting the assembled elements in a mold and injecting the seal material around the exterior of the fuel cell assembly and simultaneously permitting seal material to flow into the groove network from the exterior, thereby to form said seal and to insulate said stack.

33. A method as claimed in claim 31, which includes providing a membrane electrode assembly a proton exchange membrane and gas diffusion media on both sides of the proton exchange membrane, and providing the proton exchange membrane with an external mounting flange, and causing the seal material to bond to the mounting flange, to seal the membrane exchange assembly in position.

34. A method as claimed in claim 31, which includes providing a membrane electrode assembly including a proton exchange membrane and gas diffusion media on both sides of the proton exchange membrane, and having the seal material to bond to the proton exchange membrane.

35. A method as claimed in claim 33, which includes providing a plurality of fuel cells within the fuel cell stack, providing each fuel cell with a pair of flow field plates, providing the mounting flange and the gas diffusion

media extending to peripheries of the flow field plates and providing a seal for each fuel cell around the edges of the flange and the gas diffusion media and bonded to the flow field plates.

36. A method as claimed in claim 34, which includes providing a plurality of fuel cells within the fuel stack, providing each fuel cell with a pair of flow field plates, providing the proton exchange membrane and the gas diffusion media extending to peripheries of the flow field plates and providing a seal for each fuel cell around the edges of the proton exchange membrane and the gas diffusion media and bonded to the flow field plates.

37. A method as claimed in 31, which includes, for each fuel cell in the fuel cell assembly, providing an anode flow field plate and a cathode flow field plate having facing, front surfaces, providing groove segments in said facing, front faces of the anode and cathode flow field plates defining a groove extending around the periphery of the membrane exchange assembly, and providing the membrane exchange assembly with a periphery which terminates in said groove without extending all the way across the groove.

38. A method as claimed in 31, which includes aligning the separate elements and clamping the said separate elements, prior to injecting the seal material.

39. A method as claimed in claim 25, which includes providing a proton exchange membrane between the anode and cathode flow field plates and, providing a gas diffusion layer on either side of the proton exchange, providing each of the anode and cathode flow field plates with a recess to accommodate one of the gas diffusion layers, and clamping the anode and cathode flow field plates, such that pressure on the gas diffusion layers is determined by depths of said recesses and is unaffected by injection of the seal material.

40. A method as claimed in claim 38, which includes, after curing the seal material, one of removing the clamping of the elements whereby the seal material maintains the separate elements bonded to one another, and adjusting the clamping pressure to a final clamping pressure.

41. A method as claimed in claim 38, which includes, after clamping the separate elements together, mounting the separate elements in a mold and providing connection apertures between the groove network within the fuel cell assembly and the exterior thereof, and injecting the seal material into the mold around the exterior of the fuel cell assembly, whereby the seal material covers the exterior of the fuel cell assembly and flows through said connection apertures into the internal groove network.

42. A method as claimed in claim 41, which includes providing the mold with a profile to define individual external seals at joints between adjacent elements of the fuel cell.

43. A method as claimed in claim 23, which includes forming at least one vent for venting air from the groove network by scratching a surface of at least one of said separate elements.

44. A method as claimed in claim 24, which includes providing, for each fuel cell, a proton exchange membrane, and opposed cathode and anode flow field plates on either side of the proton exchange membrane, and offset grooves in the opposed flow field plates to prevent distortion of the proton exchange membrane during delivery of the liquid seal material.

45. A method as claimed in claim 23, which includes delivering the liquid seal material at a pressure in the range 1-2000 psig, more preferably in the range of 80-300 psig.

46. A method as claimed in claim 23, which includes providing at least two separate groove networks, injecting a separate liquid seal material

into each groove network of the fuel cell and selecting the composition of each liquid seal material, to provide compatibility with materials and liquids required for fuel cell operation and durability.

47. A method as claimed in claim 46, wherein component (a) is a vinyl terminated methyltrifluoropropyl polysiloxane homopolymer.

48. A method of forming seals in a fuel cell assembly by injecting a sealing material into a groove network within the fuel cell assembly, the method including injecting a curable seal material containing:

(a) 100 parts by weight of a polydiorganosiloxane containing two or more silicon-atom-bonded alkenyl groups in each molecule;

(b) 5-50 parts by weight of a reinforcing filler;

(c) 1-20 parts by weight of an oxide or hydroxide of an alkaline earth metal with an atomic weight of 40 or greater;

(d) an organohydrogensiloxane containing three or more silicon-atom-bonded hydrogen atoms in each molecule, the hydrogen atoms being present in an amount providing a molar ratio of silicon-atom-bonded hydrogen atoms in component (d) to silicon-atom-bonded alkenyl groups in component (a) which is in a range of 0.4:1 to 5:1; and

(e) a platinum-type metal catalyst in an amount providing 0.1-500 parts by weight of platinum-type metal per one million parts by weight of component (a).

49. A method as claimed in claim 48, wherein the seal material further comprises:

(a) 0.1-5.0 parts by weight of an organic peroxide in combination with component (e) or in place of component (e);

(b) 0.01–5.0 parts by weight of an inhibitor; and

(c) 0.01-100 parts by weight of a non-reinforcing extending filler.

50. A method as claimed in claim 48, in which the polydiorganosiloxane of component (a) is a vinyl terminated polydimethylsiloxane having a viscosity of at least 55 Pa.s (55,000 cP) or a blend of lower and higher viscosity vinyl containing polydimethylsiloxanes such that the viscosity of the blend is at least 55 Pa.s (55,000 cP).

51. A method as claimed in claim 50, wherein component (a) is a vinyl terminated trifluoropropylmethylsiloxane dimethylsiloxane copolymer in which the mole percent of methyltrifluoropropyl is 10-100 mole percent.

52. A method as claimed in claim 48, wherein component (a) is a vinyl terminated diphenylsiloxane dimethylsiloxane copolymer in which the mole percent of diphenylsiloxane is 2-50 mole percent.

53. A method as claimed in claim 48, in which component (e) is encapsulated in a thermoplastic organic polymer.

54. A method as claimed in claim 48, in which component (e) is present in an amount to provide 5-50 parts by weight of platinum type metal per one million parts by weight of component (a), and the composition is cured by heating it to a temperature of 30-120 °C.

55. A method as claimed in claim 48, in which component (e) is an organic peroxide, instead of the metal catalyst, present in an amount of 0.5-5.0 parts per 100 parts of the composition, and the composition is cured by heating it to a temperature of 100-200 °C.

56. A method as claimed in claim 48, in which the curable composition further comprises:

(l) 0.1-20 parts by weight of an adhesion promoter which is an epoxy containing organosilicon compound, the adhesion promoter being added to the composition before it is cured to improve bonding of the composition during cure.

57. A method as claimed in claim 49, in which the viscosity of the curable composition is 1,000-1,500 Pa.s (100,000-150,000 cp).

58. An electrochemical cell assembly comprising:

a plurality of separate elements;

at least one groove network extending through the electrochemical cell assembly and including at least one filling port for the groove network; and

a seal within each groove network that has been formed in place after assembly of said separate elements, wherein the seal defines a barrier between at least two elements to define a chamber for a fluid for operation of the electrochemical cell assembly.

59. A method of forming a seal in an electrochemical cell assembly comprising a plurality of separate elements, the method comprising:

(a) assembling the separate elements of the electrochemical cell assembly together;

(b) providing a groove network extending through the separate elements and a filling port open to the exterior in communication with the groove network;

(c) connecting a source of uncured liquid seal material to the filling port and injecting the seal material into the groove network to fill the groove network and simultaneously venting gas from the groove network; and

(d) curing the seal material, to form a seal in the groove network.